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DRAWINGS ATTACHED

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(54) A METHOD OF FORMING A HOLLOW ELONGATE BODY MADE OF FIBRE-REINFORCED MATERIAL

(71) We, MESSERSCHMITT-BOLKOW-BLOHM Gesellschaft mit Beschrankter Haftung, of Ottobrunn bei Munchen, 8 Munchen 80, Western Germany, a Company organised and existing under the Laws of Western Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of winding reinforcement threads onto an elongate winding core, preferably cylindrical, to form a hollow elongate body made of fibre-reinforced material, the winding being effected by the co-operation of the winding core with thread or fibre guidance devices which core and guidance devices move relatively to one another.

Hollow bodies manufactured as above can be provided at both ends, by way of example, with covers or closures, and serve as storage containers for liquids or loose materials. In order to save weight and material, the thickness of the container wall is generally as small as possible, and to achieve adequate buckling strength a number of reinforcing rings can be provided, which rings are connected to the jacket or body. Such rings have hitherto been connected to the cylinder jacket either during the forming or after the forming of the cylinder jacket, using separate movement cycles of a winding device. This has the disadvantage that two different device settings or adjustments are necessary. Moreover upon the connection of the reinforcing rings to the jacket after the completion thereof, the effective adhesion or plane of shear will be restricted simply to the peripheral surface which corresponds to the width of the reinforcing rings.

In known winding processes an expert judges the different types of winding differently because slight deviations, for example in the selection of the winding angle, lead to winding bodies with different properties. Thus, for example, peripheral or circular hoop winding leads to different results than a helical winding, although both types of winding, which are produced with the same machine, look alike. (See the report of W. Stockton and W. A. Rusell of the Society of the Plastics Industry, Inc. on 4th, 5th and 6th February 1964 in the Edgewater Beach Hotel, Chicago, Ill., regarding "Fabrication Techniques Developed in Filament Winding", published in "Annual-Technical and Management Conference—Reinforced Plastics Division).

In the case of peripheral or belt winding, each thread turn is placed precisely adjacently the preceding one. The pitch of the individual winding threads is determined only by the width of the wound threads or strips. In the case of this form of winding one speaks of the "Winding in 90° to the winding core axis", although the winding angle naturally is somewhat smaller than 90°. Such hollow body will be suitable to absorb mainly circumferential forces, whilst it is sensitive to axial loads and stresses.

In the case of helical winding, on the other hand, the thread depositing on the core is effected at a substantially more acute angle (by way of example, 60° to the winding core axis). The finished body is therefore suitable to absorb considerable longitudinal forces or tensions as well as circumferential forces, because these can to a large extent be absorbed by the wound and cemented or bonded thread or roving layers.

The object of this invention is to avoid or minimise the aforesaid drawbacks.

According to this invention we provide a method of winding reinforcement threads onto an elongate winding core to form a hollow elongate body made of fibre-reinforced material, the winding being effected by the co-operation of the winding core with thread or fibre guidance devices which core and guidance devices move relatively to one another, wherein the winding takes place simultaneously in a number of adjacent axially extending sections with which are associated at least as many said guidance devices, the

edge regions of said adjacent sections being wound overlappingly by the associated adjacent guidance device whereby the resultant formed hollow body presents thickened or reinforced portions extending around the periphery of the body and spaced apart from one another in the longitudinal direction of the body, and upon completion of the winding operation the core is removed from the resultant formed hollow elongate body. Preferably the said edge regions of said adjacent sections become the said thickened or reinforced portions of the resultant formed hollow body. Expediently the said guidance devices move in synchronism.

With the above method an overlapping of juxtaposed but simultaneously wound sections is obtained, and there also ensues upon each over-run of the thread guidance devices during the winding procedure an overlapping of the individual threads of adjacent winding layers, so that a form of "toothing" of the individual sections is obtained. Thus a more favourable stress distribution and better homogeneity of the reinforced wall parts is achieved. Furthermore, the cross-sectional shape of the reinforced wall parts can be adapted to the anticipated container load, which is possible in accordance with a preferred form of the invention by varying the periods of dwell occurring on the reversal of movement of the said guidance devices. On the other hand, cylindrical jackets manufactured in accordance with known methods are less resistant to shear in the region of the overlappings, since the effective shear planes or surfaces correspond substantially only to the width of the overlap surfaces. Moreover, dangerous local stresses are generated as soon as bending moments occur.

Reference will now be made to the accompanying drawing, illustrative of a preferred embodiment of the invention. The drawing illustrates a cylindrical hollow body with the upper part in section, almost completely wound, the lower part showing the completely wound cylinder with reinforcing rings.

The winding is effected, for example, on a winding core 2 rotating about its axis 1. The resultant formed body 3 after removal of the core 2 is the required hollow elongated body made of fibre-reinforced material and here constitutes a hollow cylindrical body with reinforcing rings 4, 5, 6, 7 formed by the winding operation now to be described. During winding, simultaneously several strands 8 to 12 are conducted by the same number of thread or fibre guiding devices 13 to 17 respectively which are synchronously reciprocated during the rotation of the core 2 to the extent of the arrows 18 to 22 respectively, in other words the experience a translational movement. They can, however, also carry out a rotary movement whilst the winding core 2 moves axially. A combination of the two movements both for the winding core 2 in the case of stationary guidance devices 13 to 17 and conversely is also possible. It will be understood that a translational motion is a movement of the guidance devices 13 to 17 parallel to the longitudinal axis of the winding core 2, or at any desired angle to the said axis. Rotation of the core and translational movement are mutually coordiated in such a way that the thread is applied at an angle to the longitudinal axis of the core and thereonto, such that optimum strength values depending on the requirements in the longitudinal and peripheral direction are obtained.

The paths identified by the arrows 18 to 22 are represented partially in dotted lines on the drawing, because the corresponding sections of the winding body 3 are not shown. The method allows variation of the length of the over-run of all of the said guidance devices, if necessary collectively, whereby the width or position of the reinforcing rings 4, 5, 6, 7 can be changed at will, even during the winding procedure.

The reciprocating movements of the guided strands 8 to 12 can overlap approximately to the extent of the desired width of the reinforcing rings 4 to 7, so that in these regions the strands or layers of winding are applied at least in double numbers. As adjacent strands or winding layers overlap, there thus ensues a type of toothing, namely on the plane of the individual threads. It is, however, also possible that individual over-runs can be approximately twice as large as the length of a section, so that the overlap zones correspond approximately to the length of a section and further reinforcing rings arise between those represented in the drawing, in other words the reinforcing rings 4 to 7 would no longer be apparent and fresh ones would arise where valleys are at present shown. The toothing of adjacent sections is thus further strengthened.

By retarding the guidance devices 13 to 17, upon each of or upon individual reversal movements, various cross-sectional shapes of the strengthening rings 4, 5, 6, 7 can be produced. The said guidance devices can be numerically controlled in known manner to produce such variation.

Through the simultaneous use of several thread or fibre guidance devices, a high working speed with comparatively low technical resources is obtained. It will be evident that elongate hollow bodies of cross-sectional shapes of other than annular, for example, cross-sections having an outer rectangular or polygonal form, can be wound by the method of this invention.

WHAT WE CLAIM IS:—

1. A method of winding reinforcement threads onto an elongate winding core to form

a hollow elongate body made of fibre-reinforced material, the winding being effected by the co-operation of the winding core with thread or fibre guidance devices which core and guidance devices move relatively to one another, wherein the winding takes place simultaneously in a number of adjacent axially extending sections with which are associated at least as many said guidance devices, the edge regions of said adjacent sections being wound overlappingly by the associated adjacent guidance device whereby the resultant formed hollow body presents thickened or reinforced portions extending around the periphery of the body and spaced apart from one another in the longitudinal direction of the body, and upon completion of the winding operation the core is removed from the resultant formed hollow elongate body.

2. A method as claimed in Claim 1 wherein the core is a cylindrical body.

3. A method as claimed in Claim 1 or Claim 2 wherein the said guidance devices move in synchronism.

4. A method as claimed in any preceding claim, in which periods of dwell, on the reversal of movement of the said guidance devices are variable.

5. A method as claimed in any preceding claim, in which the winding operation produces wound axial sections of substantially equal size.

6. A method of forming a hollow elongate body made of fibre-reinforced material substantially as herein described with reference to the accompanying drawing.

7. A hollow elongate body made of fibre-reinforced material when obtained by the method claimed in any preceding claim.

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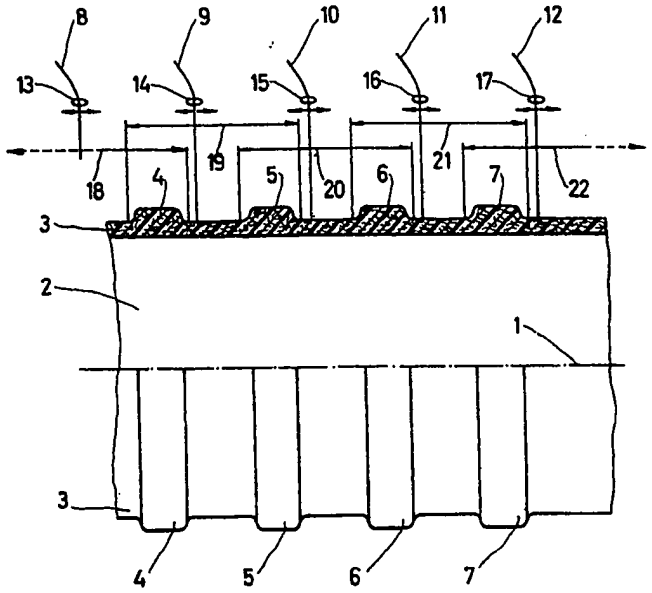
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